Title: **A Comparative Study of Nitrate Loading to Groundwater from Mound, In-Ground Pressure and At-Grade Septic Systems**

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Background/Need: Due to the sandy soil and the shallow depth to groundwater, the Central Sands area of Wisconsin is particularly susceptible to groundwater contamination from various land uses, one of these being on-site septic systems. When used on sandy soils, conventional septic systems have been shown to result in significant addition of nitrate concentrations to groundwater. There are an increasing number of alternative septic systems, largely mound or at-grade systems, installed at sites where adequate separation would not exist between the bottom of the drainfield and groundwater or bedrock for conventional systems to be used.

There is a lack of cost effective methodologies for monitoring the impact to groundwater from on-site septic systems. Proper location of monitoring wells relative to the drainfield is essential for consistent monitoring of the contaminant plume.

Objectives: 1) To evaluate the treatment efficiency of three types of pressure septic systems; mound, in-ground, and at-grade systems. 2) To develop a methodology for monitoring groundwater impacted by on-site septic systems.

Methods: Study sites were chosen from single and multiple family housing sites in Portage County which had pressure mound, at-grade, or in-ground septic systems in place for 10 years or less. Groundwater flow direction was determined at each site. The locations of the contaminant plumes resulting from the seepage beds were initially determined from specific conductivity of groundwater samples collected from 2 to 11 borings completed downgradient of each seepage bed. Two multi-level monitoring wells were then installed at each site in or near the boreholes which revealed high field specific conductivities. The upgradient monitoring well nests consisted of a piezometer placed 1.8 m into the aquifer and a smaller well screened at the water table. The downgradient monitoring well nests consisted of four wells. The shallowest well in each well nest was screened at the water table. Dosing chambers and monitoring wells were sampled quarterly and analyzed for alkalinity, total hardness, Na, COD, pH, fluorescence, $NO_2 + NO_3$, Cl, NH_4, total Kjeldahl N, conductivity, and reactive P. Dosing chamber samples were also analyzed for total P, BOD_5, and total suspended solids. The volume of effluent entering the drainfield was calculated from tank dimensions and estimated from the County site inspection reports. Pumping frequency was measured with a counter connected to the pump switch.

Results and Discussion: The amount of nitrogen discharged through the dosing chambers to drainfields ranged from 2.9 to 8.2 kg per person per year, and averaged 4.5 kg per person per year for the multiple family sites and 5.6 kg per person per year for the single family sites. Similar amounts are believed to be entering groundwater as chloride to nitrogen ratios do not change between dosing chambers and groundwater. The amount of dilution by groundwater was estimated to range from a factor of 1.3 to 3.8. Concentrations of nitrate in the contaminant plumes ranged from 21 to 108 mg/l, averaging 34 mg/l in the single family systems and 31 mg/l for the multiple family systems. All 15 systems resulted in groundwater nitrate concentrations exceeding the 10 mg/l standard. There was no statistical difference found for the different types of systems when comparing the change in chloride and nitrogen concentrations between dosing chamber and contaminant plumes. This indicates that the different types of pressure systems are accomplishing similar treatment, and result in similar concentrations of nitrogen and chloride reaching

groundwater. The multiple family systems showed a more consistent decline in nitrogen relative to chloride between the dosing chamber and groundwater. This may suggest some nitrogen loss associated with the higher hydraulic loading to multiple family systems. Sites with the highest ratio of effluent to plume nitrogen concentrations all had drainfields perpendicular to groundwater flow and all had relatively low hydraulic loading to the soils. A decrease in mean nitrogen concentrations, observed in the May 1991 groundwater sampling corresponds to a 0.7 meter rise in groundwater elevations. The highest nitrate concentrations were observed in the fall and winter of 1990 following a dry period. The effluent plumes were often vertically thin and chemically heterogenous. Two nested wells were not always adequate to characterize the plume. There was a significant relationship between the depth of the contaminant plume and the distance from the drainfield and hydraulic loading. Hydraulic gradients were difficult to evaluate at most of the study sites due to a flat water table and groundwater mounding.

Average phosphate concentrations in wastewater were 10.8 mg/l for single family systems and 8.7 mg/l for multiple family systems. The difference may be due to the presence of clothes washers and associated cleaning products in the single family systems. Phosphorous did not show up downgradient of these systems as they are fairly new, and adsorption sites of the soil are not yet saturated with phosphorous.

Conclusions/Implications/Recommendations: There was no significant difference between the treatment efficiency of pressure mound, in-ground or at-grade systems. These systems on sandy soils do not remove a significant amount of nitrogen from wastewater. Monitoring well networks for septic systems should consist of at least three multi-level well nests located downgradient of the drainfield. Four ports sampling to a depth of 3.3 m into the groundwater should be adequate for wells located within 9.8 m of the drainfield. Seasonal variability downgradient of the septic systems suggests that at least seasonal sampling is required. Worst case conditions can be anticipated in late winter or late summer, and the greatest plume dilution can be expected following both spring and fall groundwater recharge. There is a wide range in the amount of waste produced and water used by homeowners. High hydraulic loading rates allow less mixing with upgradient groundwater, especially if the drainfield is oriented parallel to the direction of groundwater flow.

Related Publications:

Nitrate-N Loading to Groundwater from Pressure Mound, In-Ground and At-Grade Septic Systems *from* On-Site Wastewater Treatment, 1994 Proceedings of the 7th International Symposium on Individual and Small Community Sewage Systems. ASAE.

Key Words: nitrate, Central Sands, phosphorus, alkalinity, septic systems

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Final Report: A final report containing more detailed information on this project is available for loan from Wisconsin's Water Library, University of Wisconsin - Madison, 1975 Willow Drive, Madison, Wisconsin 53706 (608) 262-3069.